THE CHUMASH CANOE

The Structure and Hydrodynamics of a Model

by

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FOREWORD
by
Spencer L. Rogers

The use of the plank canoe by Southern California Indians has aroused the interest and curiosity of all persons concerned with aboriginal American boat construction and navigation. It is one of the few examples of plank boat building in the New World and was impressive to the early explorers of the Pacific Coast for its versitility and seaworthy features (e. g. Font in Bolton, 1931, pp. 252-253). Unfortunately, the original examples of this craft deteriorated and disappeared soon after European penetration of the Pacific Coast. All that remained into the recent historic period were a few boat fragments, explorers' accounts and family traditions. An early illustration of what appears to be a plank canoe in the Santa Barbara region was published by Forbes (Forbes, 1839, pl. 5, op. p. 167).

In preparation for the exhibits of the Panama-California Exposition in San Diego, which opened on January 1, 1915, a replica of this type of aboriginal canoe was constructed according to the best available information. This model was built by an ageing Indian who remembered, either from personal recollection or family accounts, many details of the construction. His work was verified by the ethnographic knowledge of Dr. John P. Harrington, of the Smithsonian Institution, who supervised the construction. The completed model probably resembled as well as could be achieved a typical example of the canoe used in Pre-Hispanic times. Dr. Harrington described the canoe in the following terms when it was put on display: "A unique specimen is the plank canoe of the type seen on San Diego waters by Cabrillo and other early explorers. Made of rough hewn boards of native pine or cedar, lashed together with string of red milkweed fiber, caulked with tube *(sic)* and coated with asphaltum, these boats would stand the roughest seas and played an important part in Indian fishing and transportation. The canoes carried from two to six Indians. In them the Indians navigated not only the esteros along the shore, but ventured far out to sea, crossed to the islands or made long trips up and down the coast" (Harrington, n.d.).

After the closing of the Exposition in 1916, the model was preserved in the ethnographic collections of the San Diego Museum of Man and at times displayed. Many questions as to the design characteristics of the canoe have been asked over the years, but until recently little technical examination has been attempted other than measurements and photographs. The study reported in this paper was made for the purpose of supplementing previous descriptions by providing more information concerning the model in terms of its structural and flotation characteristics.

A SURVEY OF THE CHUMASH PLANK CANOE

by C. F. Richie

THE METHOD

A marine survey was used to describe the Chumash canoe. The method dates back to the time when a ship, captured at sea, was dry-docked and measured to obtain its lines and determine its worth and sea-keeping qualities. It is suggested that any use of the survey drawings be accompanied by use of the photographs, as no attempt was made to measure and draw each and every plank and lashing in the hull. The hydrodynamic lines of the canoe were the main consideration of this survey.

The hull is essentially flat-bottomed, and was found to be very nearly level on its base, so the survey was begun by laying the *centerline.* This was done by measuring from the tip of the bow to the tip of the stern with a chalk line and line level at an even height above the hull bottom. The designations *bow* and *stern* were affixed arbitrarily as an aid to orientation. The centerline served as a base line and reference from which the other measurements were made. Next, this centerline was measured and marked at intervals of 1½ feet from the bow to the stern. This interval distance seemed by eye to be the most satisfactory for the description of the significant hull features. Fourteen points were measured off in all. The distance between the fourteenth point and the stern is 2 feet, 4 inches.

These fourteen points were designated *sections* (see Diagram 1). At each of the sections a *section line* was drawn across the centerline at a 90 degree angle, leveled, and marked where it crossed the hull sides. This gave the hull width or *beam* at that point. Then a plumb bob was dropped to the bottom from the centerline and moved outward along the section line at 3-inch intervals toward both sides of the hull. Thus, a depth profile of each hull section was obtained relative to the height of the centerline from the bottom of the hull (see Diagram 2). Also, the true height of both hull sides was obtained by subtracting the difference between their tops and the centerline from the total centerline-to-hull-bottom distance. The heights of the left and right sides of the hull at each section were found to be surprisingly similar (especially considering the very asymmetrical nature of the canoe sides due to age and dryness). The left side was allowed to stand for both. The depth measurements for each section were then reconciled to the height of the left side of the hull at that point to give a true profile of that section from the top of the hull to the inside bottom of the hull.

A determination of structural thicknesses was then made. The thickness of the bow and stern posts was measured from their exposed, topmost ends, which had been left square. The planks were measured along their ends and edges where they made up the edge of the hull sides, or where caulking had fallen out of some of the seams. Also, thickness was gauged at lashing holes where caulking had also fallen out. The keel presented the only problem, as it was everywhere joined to the hull planking or to the bow and stern posts. In addition, it had been worked slightly concave on its top surface. A hole was drilled through the keel and plumbed for the measurement of its thickness which, allowing for the slight differences in the concave top surface, should stand for the entire structure. Further internal and external measurements support this assumption.

Knowing the thicknesses of the hull structures to be very uniform, the outside configuration of the hull was built up on the "frame work" of the inside measurements, aided by careful visual observations.

Other measurements were made to support the profile and thickness observations. The keel was measured as to length and width in relation to the centerline, as were the bow and stern posts. The angles of the bow and stern posts were measured in degrees of arc from the plane of the keel toward the center of the canoe, with the keel ends serving as the pivot points (see Diagram 3). And, finally, extra-hull features, such as the "rubbing strakes," were measured in relation to surrounding structural elements.

THE MEASUREMENTS AND SOME OBSERVATIONS

In general, the Chumash canoe measures 23 feet, 5 inches overall; 3 feet, 4 inches in beam; one foot, 8 inches in draft (see Table of Measurements). The left side of its hull is much more angular than its right side, which is bowed-out considerably. Bowing and warping of a hull are not uncommon when it has been removed from the support of water, but, for the Chumash canoe, this is especially pronounced due to the fact that there are no internal ribs or cross timbers to help hold the hull's shape. The weight of the canoe, determined by a steelyard device, is 325 pounds.

The planking is uniformly one inch thick, but varies considerably in width and length, the planks being tapered to a point in some cases. These make up the main portions of both sides of the hull. They are from 4 to 6 feet long by 7 inches wide. Where these larger planks join the shorter planks of the bow and stern on the outer hull, there are roughly beveled, rectangular blocks of wood lashed to the hull. Their purpose is open to speculation, but it seems likely that they were placed there as structural reinforcements to aid in lashing the long planks to the shorter ones, because longer ones could not be bent to meet the hull angles at the bow and stern.

The keel measures 13 feet, 3 inches overall and tapers toward the bow and stern from 9 to 4 inches wide. Where it joins the stern post it is probably squared-off, and where it joins the bow post it is probably beveled. There was no way to check on this, short of dismantling the canoe, but external measurements and observations seem to support these assumptions. The structure is not a keel in the true sense of the word, but is merely an extra-wide and thick plank to which the other hull planks are lashed. (A true keel is a central timber extending below the main hull structure and running a significant length of the hull.) Its thickness was measured through a drilled hole and was 2 3/4 inches thick. The keel has been worked slightly concave for the entire length of its upper surface. It has been hypothesized that such a feature is a vestigial remnant of an earlier dugout form of canoe (Hornell, 1970, pp. 188-192; 341-345). There is evidence that the Chumash occasionally made dugout canoes (Robinson, 1942, p. 205; Woodward, 1934, p. 120).

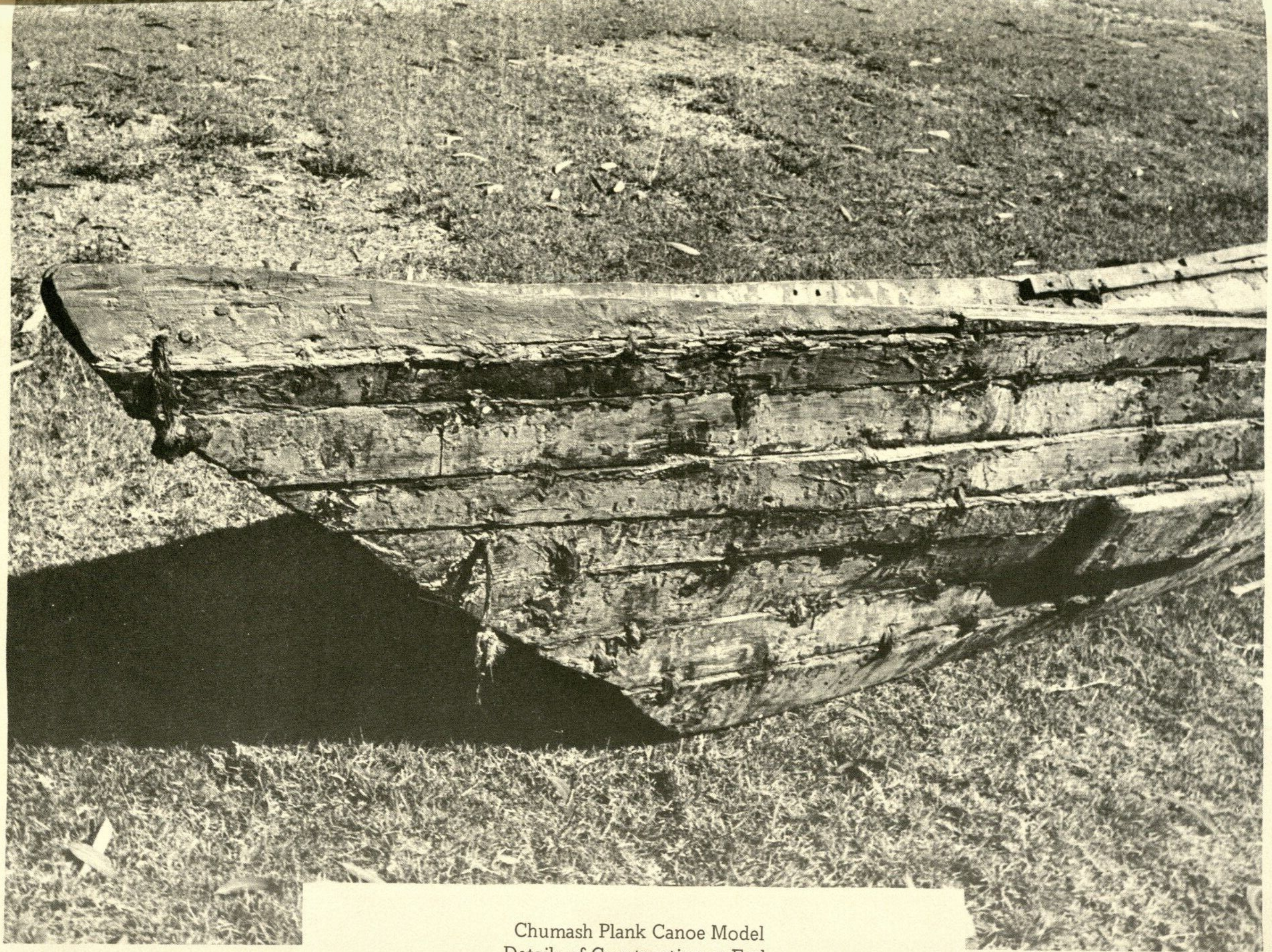
The most difficult structural features to explain in terms of their function are the narrow, downward projecting planks running along both sides of the hull amidship and just below the top of the sides. They are lashed to the hull at an acute downward angle (see Diagram 4a). It has been suggested that they were used as "rubbing strakes" to keep the double-bladed paddle from abrading the sides of the hull, but unless they are incorrectly made, they can serve no such function, because they do not extend outward far enough. Another suggestion is that they were skids used when the canoe was beached on its side. Once again, they do not project sufficiently for this purpose. The most probable explanation, I believe, is that they are hand holds on an essentially smooth hull for two or more men to lift and carry the canoe free from the surf and over the beach cobbles. It would be awkward to lift the canoe on one's shoulders and nearly impossible to lift it holding on to its sides along the edges, since they have no easily grasped projections.

Finally, much of the lashing was done with plant fibers, reported to have been "red milkweed fiber" by Harrington (Harrington, n. d.), but reported elsewhere to be maguey fiber (Robinson, 1942, p. 207). The method was to drill two holes opposite one another in the planks to be joined, and lash

them together (see Diagram 4b). Then the holes were filled with asphalt and the seams caulked with plant fiber and asphalt. In the model, rope and tar appear to have been used.

The Chumash canoe model at the San Diego Museum of Man represents a rare form of aboriginal craft in the New World, since the only other related type generally known is the seven plank *dolca* of Chile (Heizer and Massey, 1953, p. 304). The structural features of the Chumash canoe also provide some valuable and interesting clues in regard to the evolution of the wooden ship.

Chumash Plank Canoe Model
Side View

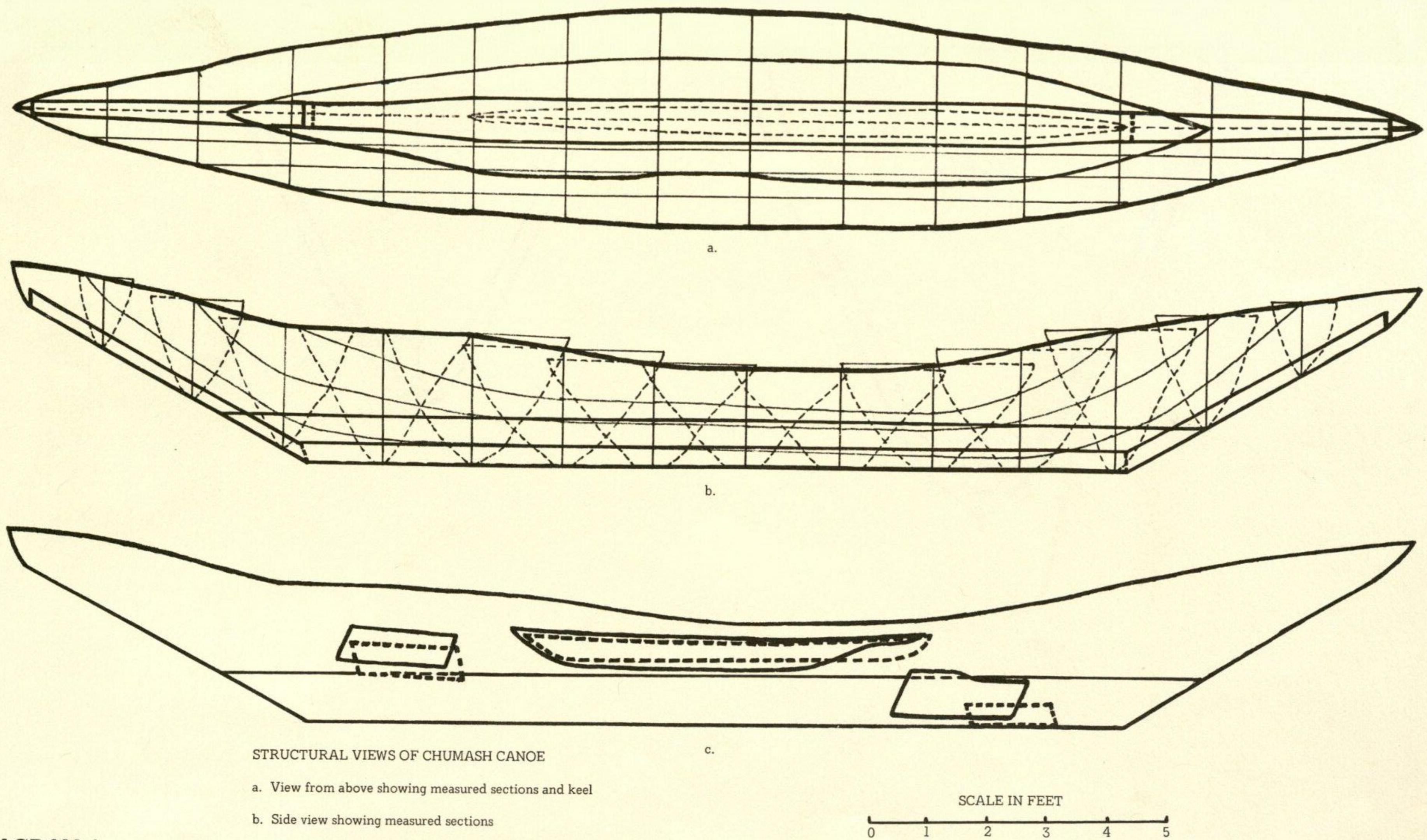


Chumash Plank Canoe Model
Details of Construction at End

CHUMASH CANOE MEASUREMENTS

Length Over-all 23 ft. 5 in.
Keel Length 13 ft. 3 in.
Keel Width 4 in. to 9 in.
Keel Thickness 2 3/4 in.
Bow and Stern Posts:
- Length 4 ft. 11 in.
- Width 4 in.
- Thickness 2 3/4 in.

Beam at the Widest Section (No. 8) 3 ft. 4 in.
Draft at Section No. 8 1 ft. 8 in.
Main Planks:
- Average length 4 ft. to 6 ft.
- Width 7 in.
- Average Thickness 1 in.



STRUCTURAL VIEWS OF CHUMASH CANOE

a. View from above showing measured sections and keel

b. Side view showing measured sections

c. Side view showing rubbing strakes and reinforcement blocks

DIAGRAM 1

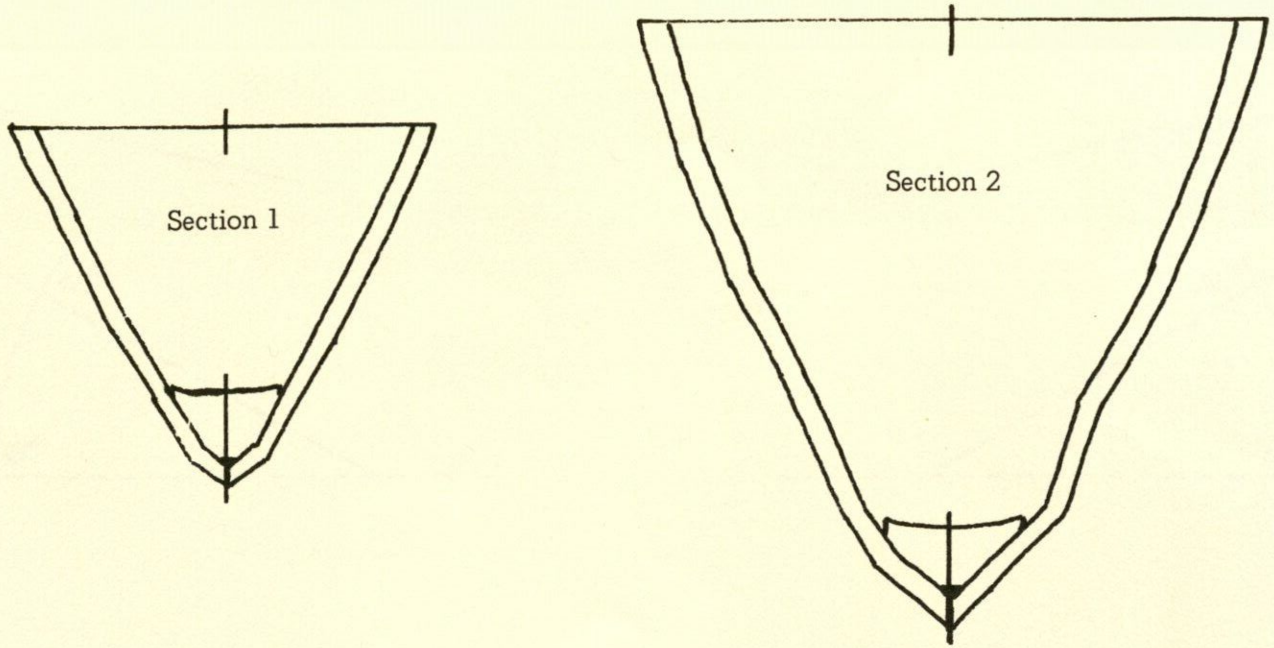


DIAGRAM 2

Cross Sections of Canoe

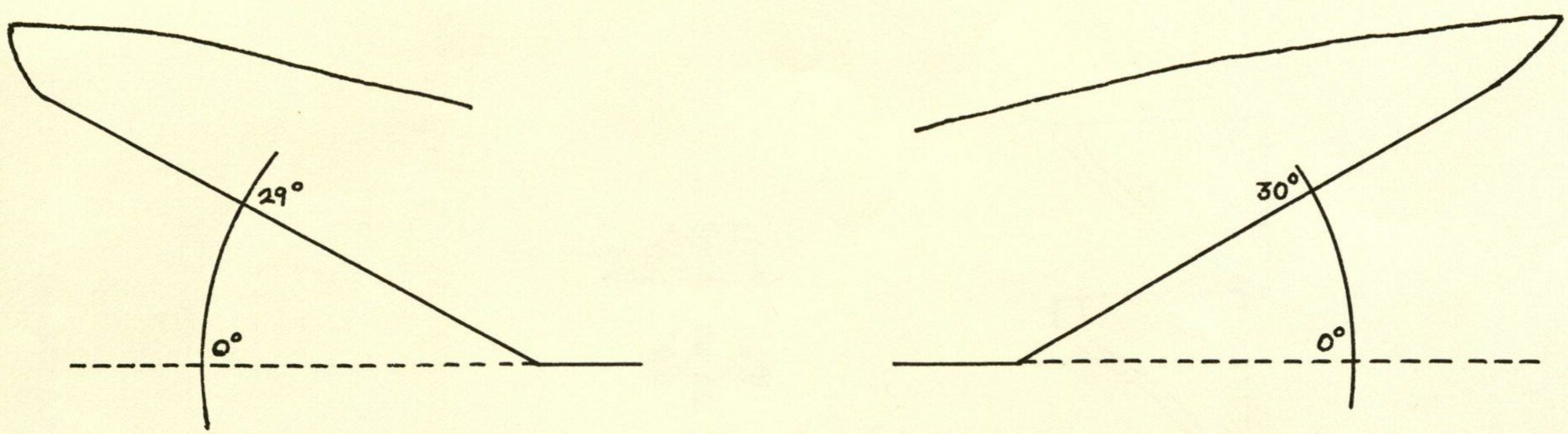
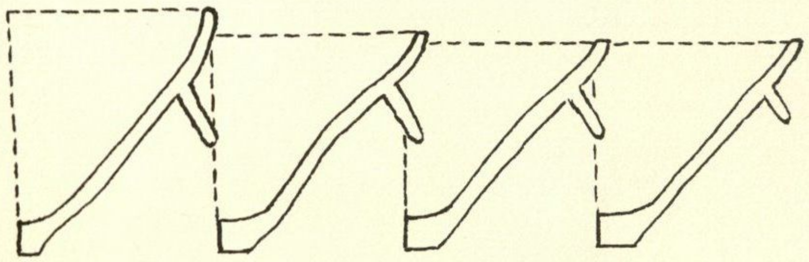
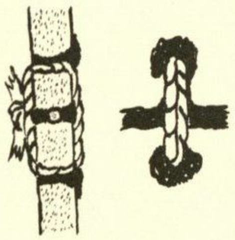


DIAGRAM 3

Bow and Stern Angles of Canoe



a.



b.

DETAILS OF CONSTRUCTION

a. Sections 7 to 9 showing rubbing strake
b. Detail of lashing

DIAGRAM 4

CALCULATIONS OF THE CANOE'S WATER LINE

by R. A. Hager

The water line can be determined by using the principle of Archimedes, which states that a floating object displaces its weight in water. The empty canoe must displace 325 pounds of water. Since sea water weighs 64 pounds per cubic foot, the canoe displaces 5.07 cubic feet of water. The question that must be answered is the following: at what height, measured from the bottom of the keel, do we obtain 5.07 cubic feet of volume?

A mathematical formula called the trapezoidal rule allows us to compute the volume, knowing the areas of the cross sections. The areas of the cross sections must be computed first. This is also done by the trapezoidal rule. Measurements were taken of the widths of each of the ten sections 3 through 12 at height intervals of 1/2 inch. By using the trapezoidal rule, we get a tabulation of the area up to height *h* of each of the ten sections. Here *h* is a multiple of 1/2 inch. For example, the width of section 6 at the height of 6½ inches is 1.29 feet, and the area from the bottom of the cross section to a height of 6½ inches is 0.36 square feet.

Knowing the cross sectional areas at a height *h* we can then use the trapezoidal rule to estimate the volume between sections 3 and 12 of height *h*. For example, for a height of 6½ inches, we get a volume of 5.07 cubic feet. The contributions to the volume of the pyramid-shaped regions on the outside of sections 3 and 12 are approximated by pyramids. The specific formula used to obtain the total volume is:

$$V = \frac{h}{3}(1.6)(A_3 + A_{12}) + \frac{h}{2}\left[A_3 + 2A_4 + 2A_5 + 2A_6 + 2A_7 + 2A_4 + 2A_{10} + 2A_{11} + A_{12}\right]$$

where A_3 is the area of section 3, A_4 the area of section 4, etc.

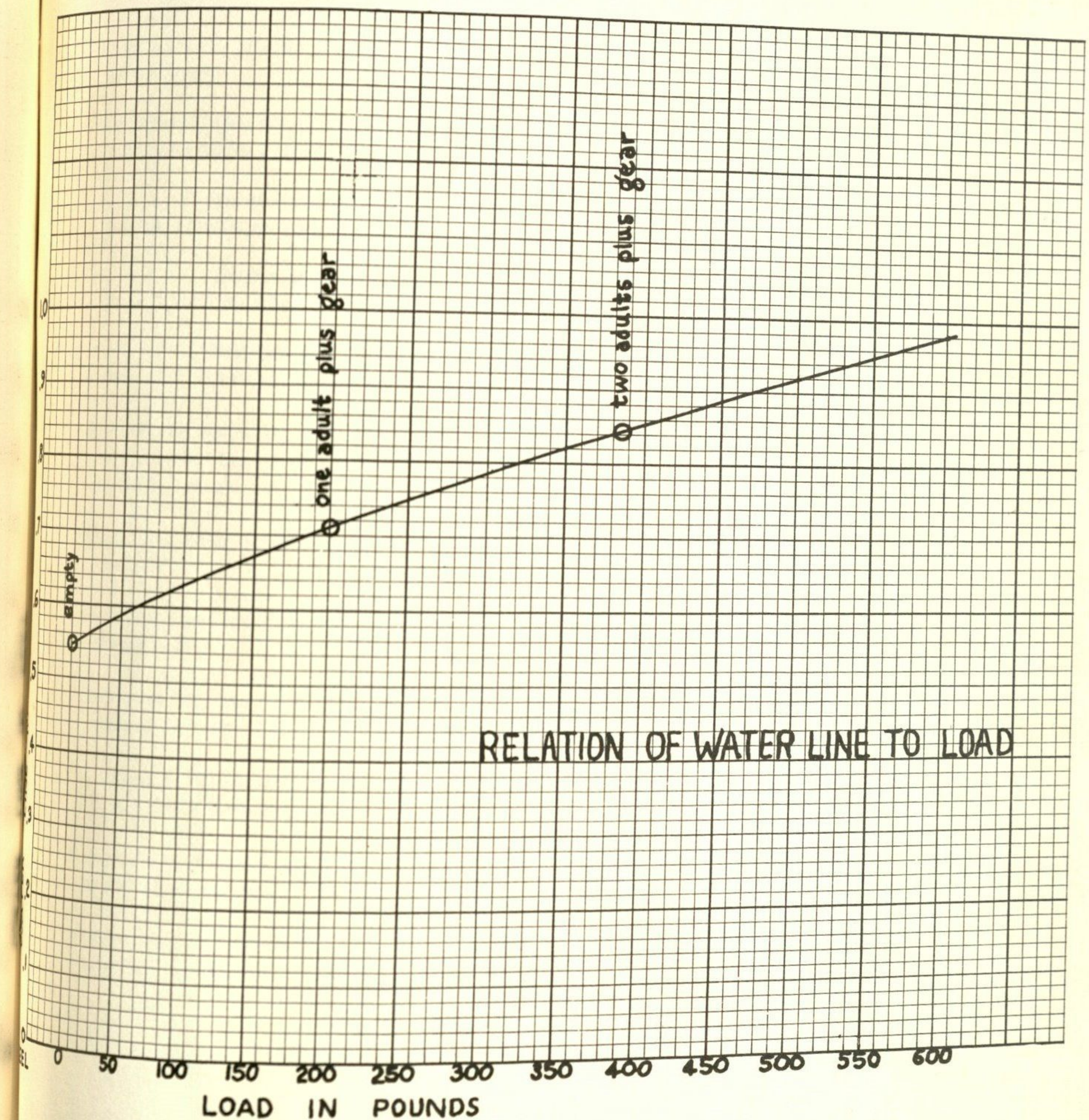
The actual computations are omitted, but a sample for heights of 0, 6, 6½, 7, and 12 inches is included.

Section Number

h	3	4	5	6	7	8	9	10	11	12	V
0	.13	.14	.19	.16	.17	.26	.23	.15	.21	.15	0 0
6	.58 .18	.67 .19	1.14 .34	1.21 .35	1.52 .45	1.52 .45	1.36 .39	1.28 .34	1.18 .36	.77 .23	4.41 4.52
6½	.61 .20	.72 .22	1.19 .39	1.29 .41	1.60 .52	1.60 .52	1.44 .45	1.35 .40	1.25 .41	.80 .26	5.07 5.20
7	.65 .25	.79 .25	1.26 .44	1.39 .42	1.68 .59	1.68 .59	1.53 .51	1.43 .45	1.37 .47	.85 .30	5.77 5.94
12	1.05 .56	1.51 .71	1.87 1.08	2.18 1.17	2.23 1.22	2.42 1.44	2.34 1.32	2.23 1.21	2.06 1.17	1.44 .78	15.07 15.78

The first column under each section number is the width in feet of that section at the given height in inches. The second column is the area in square feet between 0 and h. The first column under V is the volume between sections 3 and 12, while the second column under V is the volume including the pyramid-shaped regions outside of sections 3 and 12. It is this volume which leads to the water line.

The result of all the calculations is shown graphically in the accompanying curve (see graph).



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